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Modelling Impacts of Urban Freight Terminal Location Decisions

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Abstract

This paper presents the results of research into the evaluation of alternative scenarios for freight terminal location in an urban area in Australia. The research combines the use of a strategic transport model for overall freight demand forecasting, with cost assessment of the specific impacts of locating future terminals in selected areas. Outputs of the model were used to evaluate the impacts of urban freight terminal location decisions on all traffic in the road network. The work includes freight trip generation, using strategic transport modelling software (VISUM) to forecast future patterns of urban freight flows, calibration of the model, and option testing using a case-study in South East Queensland to predict the transport cost impacts of several locations for intermodal terminals**.**

Keywords: Intermodal freight terminal, freight trip generation, urban freight flows, strategic transport modelling, VISUM modelling.

Introduction

The movement of freight within a country, as well as imports and exports, play a significant role in the total costs of goods and services. This is particularly so in countries such as Australia and China, which rely on export and imports to a large extent. It is therefore imperative that freight transport costs are kept to a minimum. It is also important that the negative impacts of freight transport, such as environmental effects, are minimized. Road transport is one of the most cost-effective and flexible choice for less time sensitive freight over short to medium distances, for instance, local and regional levels. However, increasing truck traffic causes undesirable burdens to road users and community, including air pollution, traffic congestion, pavement deterioration, traffic safety, and sustainability.

In a road and rail intermodal transport system, a freight terminal is one of the most important elements that allows freight interchange between modes to take place.

Evaluation of Terminal Location

Operating cost is one of the key parameters that most of the operation research (OR) tries to minimize in finding the optimal location of the terminal. Unlike direct delivery, total cost of intermodal freight transportation does not comprise only line-hauling but also terminal operating cost. Such combination makes a formulation of objective functions for optimizing intermodal freight terminal location become

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complicated and usually needs to be solved by heuristics techniques as reviewed by Sirikijpanichkul and Ferreira (2005).

Strategic transport models are an alternative to facilitate the estimation of transport-related inputs for use in the objective functions of evaluation models. The use of the model can be justified by its ability to:

- forecast future patterns of urban freight flows based on available demographic and land-use data,
- estimate travel time, delay, and environmental impacts based on traffic condition in the network,
- modelling mode and route choice based on utilities of each transport mode and travel route, respectively.

Regardless of the usefulness of strategic transport models, the following limitations should carefully be taken into account.

- establishing and validating the models can be time and budget consuming especially when the models are large or require a lot of details.
- strategic transport models are suitable when there is a few discrete number of terminal location choices and when a set of solutions is made from which the final solution cannot easily be distinguished by an Operations research (OR) study. For continuous and network location problem, traditional OR approaches are more appropriate as they tend to provide a more cost-effective and quicker solution.

The Proposed Evaluation Model

This research combined the use of strategic transport models for overall freight demand forecasting, with cost assessment of the specific impacts of locating future terminals in selected areas. Outputs of the model can be used to evaluate the impacts of urban freight terminal location decisions on all traffic in the road network. The structure of proposed evaluation model is illustrated in Figure 1. To evaluate the impacts of urban freight terminal location decisions, a bespoke transport and land use allocation model was proposed. The model requires freight transport network, land use for freight activities, and terminal location choices data as inputs. Land use data are essential to predict freight transport demand generated and attracted to each travel zone. A cost matrix representing travel cost between each origin and destination (OD) pair is also required. Freight transport together with pre-estimated passenger car demand matrices were then assigned to the freight transport network. Travel time on the links, which is the most important measure to be used in the other evaluation models, is subject to traffic volume within each assignment and calculated by using the volume-delay functions. Cost matrix would also be updated and affected freight transport demand matrix until the network reaches equilibrium.

Once the model is validated, it can be used to evaluate the impacts of urban freight terminal location decisions on all traffic in the road network. It is assumed that a number of users of the existing terminals will be diverted to a new terminal.

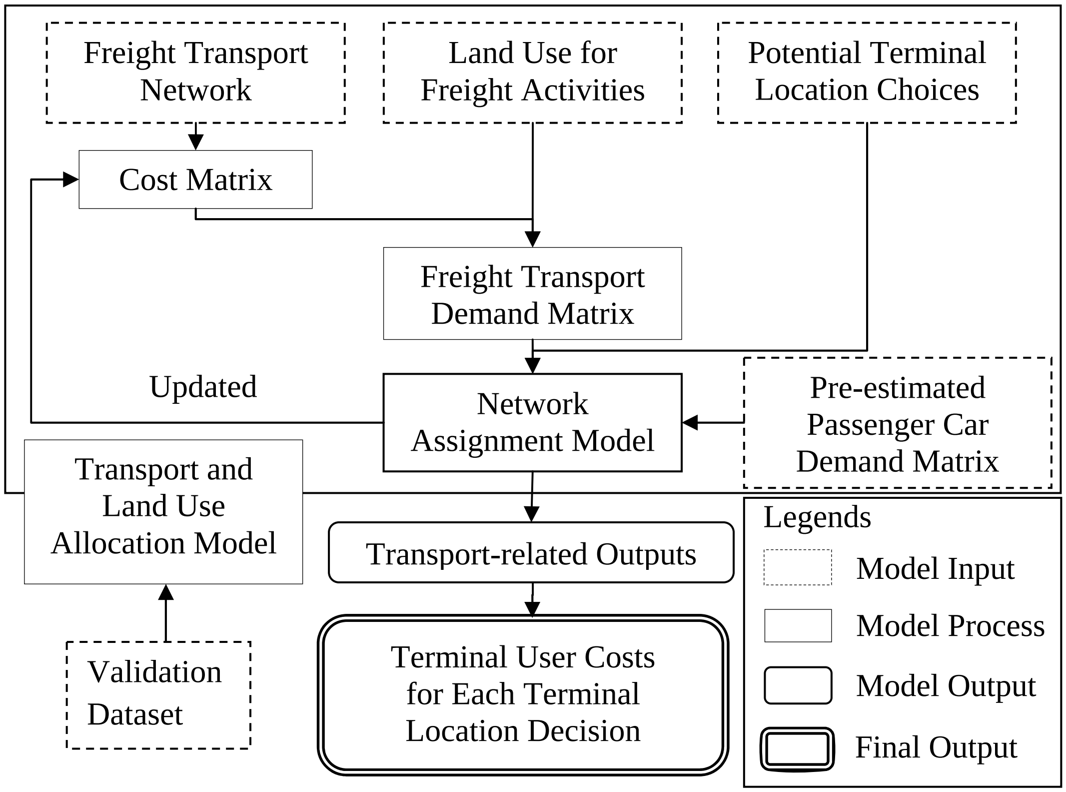

Figure 1. Proposed Model for Evaluating Impacts of Urban Freight Terminal Location Decisions

Although it might take a slightly longer distance to access a new terminal, users may prefer to do so if they find that it takes less time. Such travel behaviour is included in the model as it affects a level of terminal usage and route choices for local traffic. The details of induced traffic are explained in details by Sirikijpanichkul (2007). In addition, a number of terminal users according to the growth of future freight demand, constrained by capacity of transport links and terminals, will be attracted to the terminals.

The outputs from the model was used to determine total terminal user costs to assess the specific impacts of locating future terminals in selected areas. Terminal user cost is composed of truck transportation, user terminal operation, and line-haul rail transport costs. Each cost component requires specific transport-related outputs resulting from the model as shown in Table 1. The full sets of parameters and formulation of each terminal user cost component are shown in Sirikijpanichkul (2007).

Case Study: South East Queensland, Australia

Locating a future intermodal freight terminal in South East Queensland (SEQ) is selected as a case study for this research as shown in Figure 2.

Table 1. Transport-related Outputs for Each Terminal User Cost Component

Cost Component	Outputs from Transport and Land Use Allocation Model
1) Truck Transportation Cost • Truck Operating Cost • Truck Travel Time Cost • Truck Travel Delay Cost	• Total vehicle kilometre travelled for articulated trucks; • Total vehicle hour travelled for articulated trucks; • Total vehicle delay travelled for articulated trucks,
2) User Terminal Operating Cost • Lifting Cost • Container Storage Cost • Truck Waiting Time Cost at Terminal	• Average daily number of articulated truck trips entering and leaving terminal zones,
3) Line-haul Rail Transportation Cost • Rail Operating Cost • Rail Travel-time Cost • Rail-rail Transfer Cost and • Rail Travel Delay Cost	• Freight share and distribution by rail,

SEQ is also considered a gateway for interstate trade between Queensland and other states. The freight moves by a combination of road and rail to SEQ where most of the freight is destined. As a consequence, there is a large concentration of Queensland's non-bulk freight in this region. The region also includes the Port of Brisbane that is the major shipping gateway to Queensland. It handles most of the imported general freight for Queensland, and the exports of rural production from southern Queensland and northern New South Wales (NSW). The SEQ Intermodal Freight Terminal Study (SEQIFTS) considered the need for and preferred locations for additional intermodal land transport (road-rail) freight terminals within SEQ within a time horizon of 25 years. The analysis showed that one addition terminal is needed in the year 2026 (GHD, 2005). Accordingly, seven candidate sites from SEQIFTS as shown in Figure 2 were selected for the analysis in this study.

In this study, the strategic transport modelling package, VISUM was selected as a modelling tool for establishing the transport network model. The entire freight transport network was established based on the current network data provided by Department of Main Roads and Queensland Transport. The study area was divided based on freight activities and natural physical barriers into 88 travel zones including 69 internal and 19 external zones. Two internal zones including Port of Brisbane and Acacia Ridge Intermodal Terminal were considered as intermodal freight domain area so they were treated as special generator zones. Articulated truck is the only mode that terminal users use to distribute containerized freight between freight terminal and the end consigners or consignees.

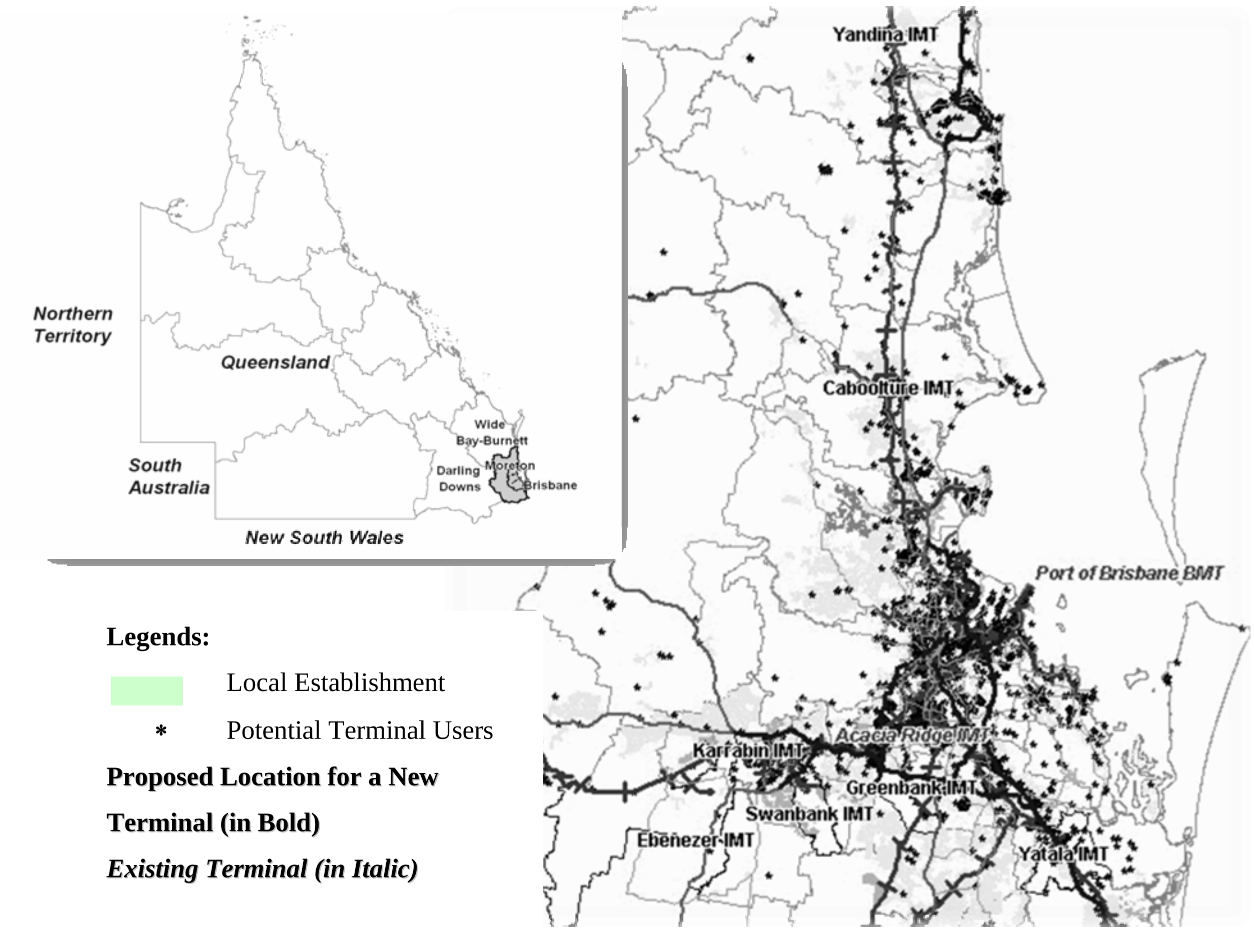

Figure 2. Potential Terminal Location Sites in South East Queensland for the Future Year 2026 (Source: Queensland Transport)

To estimate the number of articulated trucks generated from each travel zone, a relationship between trip ends and freight activities within the zone was established. Due to the lack of trip generation survey data, validated trip ends from the previous Brisbane freight matrix study by APC (2005) was analyzed using multiple regression analysis against various potential freight predictors within each travel zone. It was found a number of rigid and articulated truck trip ends was related to industrial; retail and service employment at a statistically significant level. For the Port of Brisbane and Acacia Ridge Intermodal Terminal, a number of rigid and articulated truck trip ends was closely related to container trade forecast in Twenty-foot Equivalent Unit (TEU's). Using the assumed value of time and vehicle operating cost, trip distribution model was established and the rigid and articulated truck trip matrices were estimated. Both trip generation and distribution were validated according to the validation guidelines in ATC (2006).

Evaluation Results

Net changes in total terminal user costs affected by each terminal location decision were calculated based on transport-related outputs from the model as shown in Figure 3. The results show that Yatala is the most suitable location for a new intermodal freight terminal in term of net benefits resulting from total reduction in terminal user costs, followed by Swanbank and Greenbank. The findings also show that effects of a new terminal on reducing total terminal user cost are highly influenced by truck transportation cost of terminal users followed by user terminal operating and line-haul rail transport costs by the proportion of approximately 46 %; 33 %; and 21 %, respectively. However, it could not be simply concluded that the option that cause the most reduction in truck transport cost will always be the best solution as it was assumed in most of the OR research. For example, net reduction of truck transport cost for Swanbank scenario is less than that of Greenbank; Karrabin; and Yandina. However, net change in total terminal user costs of Swanbank is the highest of all.

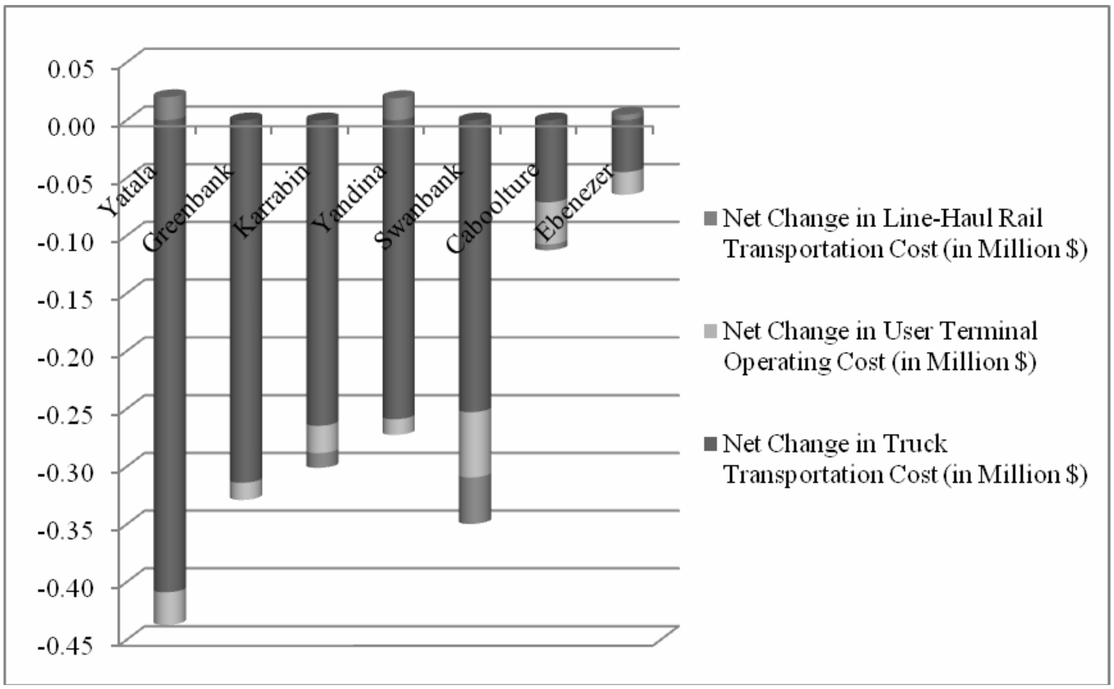

Figure 3. Impacts of Urban Freight Terminal Location Decisions

Conclusions

This research demonstrated that a strategic transport model was proven to be a useful tool to provide transport-related outputs for the objective functions formulated by each stakeholder in the terminal location decision problem. In this study, only the impacts of terminal location decisions on terminal user costs were presented. Application of the model to evaluate different impacts of terminal location decision on other stakeholders, such as environmental impacts on local community should also be investigated in future research.

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References

Adam Pekol Consulting. (2005). *Brisbane freight matrix*, Final Report, Queensland Transport, Brisbane.

Australian Transport Council. (2006). *National guidelines for transport system management in Australia,* Commonwealth of Australia.

GHD. (2005). *SEQ freight intermodal terminal study: Stage 2 additional site needs investigation - Final report,* Queensland Transport Rail Ports & Freight, Brisbane.

Sirikijpanichkul, A. and Ferreira, L. (2005). "Multi-Objective evaluation of intermodal freight terminal location decisions." *Proceedings of the 27th Conference of Australian Institute of Transport Research (CAITR)*, Queensland University of Technology (QUT), Brisbane, 1-16.

Sirikijpanichkul, A. (2007). *Multi-Objective evaluation of intermodal freight terminal location decisions*, PhD Thesis, Queensland University of Technology (QUT), Brisbane [In Press].